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MINE EXPLOSIONS AND FIRES IN THE UNITED STATES DURING THE FISCAL YEAR WHICH ENDED JUNE 30, 1932

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BY

D. HARRINGTON

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MINE EXPLOSIONS AND FIRES IN THE UNITED STATES DURING THE FISCAL YEAR WHICH ENDED JUNE 30, 1932 1/

By D. Harrington 2/

The fiscal year which ended June 30, 1932, although one of acute financial depression was, nevertheless, one of distinct encouragement to those who have long struggled against the much too prevalent occurrence of accidents in coal mines, especially of coal mine fire and explosion disasters, both of which are now known to be readily preventable. Table 1 summarizes some important information about explosions in the United States coal mines for the fiscal year which ended June 30, 1932, insofar as such information is available to the safety division of the United States Bureau of Mines, the personnel of which are under instruction to get in touch with and report on all mine explosions in their respective districts, including not only those occurrences with loss of life but also those in which fortunately no lives are affected.

Table 1 gives data on 33 ignitions in 10 States with a total of 87 deaths for the year; the number of ignitions (33) is considerably greater than the number (26) for the previous fiscal year, and is exactly the average number for the past four fiscal years; the number killed in the 33 ignitions (87) is materially lower than that (217) for the preceding fiscal year or the average (150) for the past four fiscal years.

The States with the greatest number of deaths from explosions in the fiscal year ending June 30, 1932, were Virginia, 54; West Virginia, 11; Pennsylvania, 7 (6 being in anthracite mines); Alabama and Colorado, 4 each; Illinois and Kentucky, 3 each; and Maryland, 1. The greatest number of ignitions listed was that for West Virginia, 7; then came Pennsylvania with 6 (2 being in anthracite mines); Alabama with 5; Colorado, Illinois, Tennessee and Virginia, 3 each; and California, Kentucky, and Maryland, 1 each. The 1931-32 record as given in Table 1 includes several States which were not listed in the previous year: Colorado, Kentucky, Maryland, Tennessee.

1/ The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6680."

2/ Chief engineer, Safety division, U. S. Bureau of Mines.

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Table 1. - Summary of mine explosions by States, July 1, 1931, to June 30, 1932

	Lighting				Fatalities by ignition causes									
	Open	Closed	Unknown or no lights	Total mine explosions	Electricity		Open lights or smoking		Explosives		Unknown		Total	
					Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions
Alabama	1/ 3	1/ 2	1/ 1	1/ 6	4	1	0	2/ 3	-	-	0	1	4	5
California ..	-	-	1	1	-	-	-	-	-	-	0	1	0	1
Colorado	1	1	1	3	-	1	3	1	1	1	-	-	4	3
Illinois	1	2	-	3	1	1	-	-	1	1	1	1	3	3
Kentucky	-	1	-	1	-	-	3	1	-	-	-	-	3	1
Maryland	1	-	-	1	-	-	1	1	-	-	-	-	1	1
Pennsylvania.	2	3	1	6	0	2	5	2	2	2	-	-	7	6
Tennessee ...	3	-	-	3	-	-	0	3	-	-	-	-	0	3
Virginia	2	1	-	3	-	-	16	2	38	1	-	-	54	3
West Virginia	2	5	-	7	6	5	5	2	-	-	-	-	11	7
Total United States, fiscal year ended June 30, 1932	1/15	1/15	1/ 4	1/34	11	10	33	15	42	5	1	3	87	33
Total United Statos, fiscal year ended June 30, 1931	12	15	0	1/26	143	9	56	11	18	6	0	0	217	26
Total United States, fiscal year ended June 30, 1930	8	25	1	34	154	18	21	8	24	6	0	2	199	34
Total United States, fiscal year ended June 30, 1929	18	19	1	38	33	18	14	11	26	8	6	1	139	38

1/ Mixed lights used in one mine.
2/ Ignition of methanein a metal mine.

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and Virginia. Indiana, New Mexico, Ohio, Oklahoma, and Washington which were in the similar tabulation for the previous year are fortunately absent from this year's list.

By far the most significant feature brought out by Table 1 is the fact that but 11 persons were killed in the past fiscal year in explosions caused by electricity, a number of fatalities which compares very favorably with the 143 killed by explosions of electrical origin in the previous year, or the average of 100 killed similarly for the past four years. Another favorable phase of the matter of electrical ignitions is that while there were 10 ignitions against an average of 14 for the past four years, the fact that these 10 incipient explosions were prevented from spreading or "extending" with the taking of large numbers of lives, as has been usual in the past, is a matter for national congratulation. Unquestionably rock-dusting has been instrumental in "snuffing out" several of these ignitions and thereby preventing coal-dust from augmenting or propagating the flame and violence. West Virginia had the greatest number of electrical ignitions, (5), with 6 fatalities; Pennsylvania had 2 electrical ignitions listed but with no fatalities; Alabama had 1 electrical ignition with 4 deaths; and Illinois 1 ignition with 1 fatality.

There were 15 ignitions by open lights or smoking (one was in a metal mine and killed nobody but burned one person) against 11 in the previous year and 11 as an average for the past four years; the deaths numbered 33 as compared to 56 in the previous year and an average of 31 for the past four years. Open-light ignitions were distributed as follows: Virginia, 2 with 16 deaths; West Virginia and Pennsylvania, each 2 with 5 deaths; Kentucky and Colorado, each 1 with 3 deaths; Maryland, 1 with only 1 fatality; and Alabama and Tennessee, each 3 without fatalities.

Explosions originated by blasting with explosives numbered 5, with fatalities totalling 42; the number of ignitions of similar kind in the previous year was 6, and the average for the past 4 years was 6; the number killed by ignitions from explosives in the previous year reached 18 and the average for the past four years was 27. Hence, explosions initiated by explosives had a materially heavier death toll in the fiscal year 1931-32 than in any for several years past.

Three explosions with igniting agency unknown and with but one death, are listed in the tabulation for the past year, showing one each in Alabama, California, and Illinois.

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Table 2. - Comparison of explosion ignition causes, fiscal years 1927-28 to 1931-32, inclusive

Years	Ignitions by electricity		Ignitions by open lights or smoking		Ignitions by explosions		Ignitions by unknown causes		Total	
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
1927-28	14	45.1	12	38.7	3	9.7	2	6.5	31	100.00
1928-29	18	47.4	11	29.0	8	21.0	1	2.6	38	100.00
1929-30	18	52.5	8	23.5	6	18.0	2	6.0	34	100.00
1930-31	9	34.6	11	42.3	6	23.1	0	0.0	26	100.00
1931-32	10	30.1	15	45.5	5	15.2	3	9.2	33	100.00
Total	69	42.6	57	35.2	28	17.3	8	4.9	162	100.00

Table 2 gives available data as to the causes of explosions in the mines of the United States during the past five fiscal years, as reported to the safety division of the United States Bureau of Mines. It will be seen that 162 explosions occurred in the 5-year period, an average of about 32 per year, and that there were 33 in the fiscal year which ended June 30, 1932. Sixty-nine of these or 42.6 per cent were of electrical origin; 57 or 35.2 per cent were caused by open lights or smoking; 28 or 17.3 per cent were caused by explosives, and 8 or 4.9 per cent were of unknown origin. Explosions of electrical origin caused but 30.1 per cent of the explosions in the past year, a much lower percentage than that for any other of the past five years; this indicates definitely that greater care is being taken with electricity in our mines now than in the relatively recent past, because as the years pass, the degree of mechanization of our mines, chiefly with equipment electrically operated, increases considerably, and there might well be expected an increase of explosions of electrical origin rather than the decrease which has actually occurred.

For the 5-year period 35.2 per cent of the mine explosions in the United States were started by open lights or smoking; for the year which ended June 30, 1932, this percentage was 45.5 and for the previous year was 42.3; hence, the percentage of explosions originating through open lights or smoking is increasing. This is entirely unnecessary and wholly inexcusable, as neither open lights nor smoking should be allowed in any mine, coal or metal, in the United States today.

In the past five years 17.3 per cent of the explosions were due to explosives, the number in the past fiscal year being but 15.2 per cent of the total for that year, hence a little progress was made last year insofar as number of explosions is concerned; this progress, however, is not apparent if the percentage of fatalities is considered, as is done in Table 3.

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Table 3. - Comparison of explosion fatalities by ignition causes, fiscal years 1927-28 to 1931-32, inclusive

	Electricity		Open lights		Explosives		Unknown		Total	
	Number killed	Per cent	Number killed	Per cent	Number killed	Per cent	Number killed	Per cent	Number killed	Per cent
1927-28	282	82.5	49	14.3	9	2.6	2	0.6	342	100
1928-29	93	66.9	14	10.1	26	18.7	6	4.3	139	100
1929-30	154	77.6	21	10.5	24	12.0	0	0.0	199	100
1930-31	143	65.9	56	25.8	18	8.3	0	0.0	217	100
1931-32	11	12.7	33	38.0	42	48.2	1	1.1	87	100
Total (5 years)	683	69.4	173	17.6	119	12.1	9	0.9	984	100

Table 3 conveys the appalling information that in the past five years, 984 persons (or but few short of 1000) have been killed by explosions in the mines of the United States; this is the more distressing (one might almost say the more disgraceful) when it is considered that explosions in mines are absolutely preventable and occur only because of negligence or carelessness. The average number of deaths from explosions in mines in the United States annually for the past five fiscal years is 197; the most cheerful part of this picture is that the 87 deaths from explosions in the mines of the United States for the last fiscal year is far better than the 217 of the previous year or the 199 of the year before that, and in fact is more favorable than for any fiscal year in the present century.

In the 5-year period covered in Table 3, it will be noted that 683 fatalities or 69.4 per cent of the deaths from explosions have occurred in explosions of electrical origin; in other words, nearly 70 per cent of the deaths from explosions in our mines for the past five fiscal years have been due to carelessness in the installation or use of electricity or electrical equipment in our mines, certainly a severe indictment of so-called up-to-date mechanized mining. These figures interpreted in another way show that the past five fiscal years have an average of 137 deaths annually by explosions of electrical origin in the mines of the United States--by no means a creditable record for our much-vaunted progressive up-to-date mining methods and mining equipment. The brighter side is the fact that in the past fiscal year but 11 persons, or 12.7 per cent, of those killed in explosions in the mines of the United States met their death in explosions of electrical origin--a much better record than the 143 deaths and 65.9 per cent of the previous year, or the 154 deaths and 77.5 per cent of the year before that.

Open lights (or smoking) caused explosions which resulted in 173 fatalities in our mines during the past five fiscal years, this being 17.6 per cent of the fatalities from explosions for the 5-year period; this means that an average of 35 lives annually have been sacrificed in explosions in our mines due to a persistent clinging to the use of open lights, which are less efficient and far more dangerous than the readily available electric lamps, or in some cases to allowing smoking in mines, notwithstanding the fact that smoking in mines is known to be definitely dangerous and wholly unnecessary.

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In the past fiscal year 33 deaths, or essentially the average for the past five years, were due to explosions started by open lights or smoking; this number is considerably more favorable than the 56 in the previous year, but materially worse than the 21 of the year before that. Thirteen of the 33 deaths from explosions started by open lights or smoking in coal mines in the past fiscal year were due to smoking, which caused 3 explosions; all of these explosions were in closed-light mines in which it was against the law to smoke.

In the past five fiscal years 119 persons have been killed in explosions initiated by explosives--12.1 per cent of the total fatalities from explosions started by explosives in the past five years. Hence, annually for the 5-year period, 24 persons in United States mines have lost their lives in explosions due to use or abuse of explosives. The past fiscal year with 42 deaths in explosions started by explosives has by far the worst record of any of the five years, there having been but 18 such deaths in the previous year and but 24 in the year before that. Every one of the 42 lives lost last year in these explosions was sacrificed to the use of methods of blasting known to be dangerous, including use of dynamite or various kinds of black powder, and of fuse instead of employing readily available and reasonably safe methods of blasting with permissible explosives detonated electrically.

Table 4 gives available data on electrical ignitions which caused explosions in the mines of the United States for the past four fiscal years; these electrical ignitions totalled 55 for the four years, with 10 of them causing 11 fatalities during the year which ended June 30, 1932. Of these 55 explosions of electrical origin, at least 11 (possibly 12) were caused by trolley or cable-reel locomotives, there being one in the past year; at least 15 (possibly 16) were caused by nonpermissible mining machines, there being 3 with 7 fatalities and 7 injured in the past year; 7 were due to nonpermissible electrical motors, 1 to a nonpermissible shot-firing battery, 2 to cable "nips" or cable blow-out, 2 to nonpermissible electric drills, 4 to nonpermissible storage battery locomotives, 4 to faulty wiring, 4 to trolley wires, and 5 to miscellaneous electric arcs. It is significant that of the 55 explosions of electrical origin in the mines of the United States during the past four fiscal years, 42 were due to various types of nonpermissible electrical equipment; certainly this should convey its own lesson.

Some years ago the use (or misuse) of explosives constituted the main cause of ignitions which resulted in explosions in our coal mines, and later on when our mining companies learned to curb this hazard, the main cause of ignitions which led to explosions was the use of open lights, and in recent years electricity or electric arcs have been the chief offending agencies. Before 1913 or 1914, the available closed lights for use in coal mines were only the decidedly inadequate lights obtainable from the flame safety lamp, and these lamps were so objectionable from many points of view that they were used for general underground purposes only where gas conditions were decidedly dangerous. With the advent of the modern electric cap lamps, many of them were used because of the fact that they were less cumbersome than the flame safety lamp, and were almost fool-proof as to prevention of ignitions of gas or dust; moreover, they gave a stronger and more dependable

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Table 4. - Electrical causes of explosions

Causes	Number of ignitions					Killed, 1931-1932	Injured, 1931-1932
	1928-1929 [1]	1929-1930 [2]	1930-1931 [3]	1931-1932	Total, four years		
Trolley or cable-reel locomotive	[4] 5	5	1	1	[4] 11	0	2
Nonpermissible mining machine	[5] 5	5	3	3	[5] 15	7	7
Nonpermissible motor	4	3	0	0	7	0	0
Nonpermissible shot-firing battery	0	[6] 2	[6] 3	1	1	0	0
Cable nips or blow-out	0	2	0	0	2	0	0
Nonpermissible electric drill	0	0	0	2	2	1	6
Nonpermissible storage-battery locomotive	1	1	2	0	4	0	0
Faulty wiring	2	2	0	0	4	0	0
Trolley wire	1	0	2	1	4	2	0
Electric arc	2	0	1	2	5	1	3
Total ignitions	18	18	9	10	55	11	18

1/ See Information Circular 6178.
2/ See Information Circular 6419.
3/ See Information Circular 6540.
4/ One not included in totals; may have been from open light, and hence is assigned to open lights or smoking.
5/ One not included in totals; may have been from smoking, and hence is assigned to open lights or smoking.
6/ Not included in totals; may have been from overcharged shots, and hence is assigned to explosives accidents.

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light than did the flame safety lamp, though candor compels the statement that the amount of light afforded by the early electric cap lamps was anything but adequate. At present there are available electric cap lamps almost absolutely safe and much more efficient than any other type of portable light for the miner, yet only about half of the coal miners of the United States use them. There is no record of an explosion started by an electric cap lamp, and as shown in Table 2, out of 162 explosions in the past five fiscal years, open lights (or smoking) are responsible for 57 or 35.2 per cent of the explosions in the 5-year period. Unfortunately, while the adoption of closed lights (which in the United States now means the electric cap lamp) prevents ignitions of gas or dust by the lights, there frequently are inefficiencies in operating practice which accompany installation of closed lights and which sooner or later are likely to result in explosions. Table 5 gives some interesting data as to the type of lighting in the mines of the United States which have had explosions in the past five fiscal years.

Table 5. - Comparison of lighting in mines where explosions occurred, fiscal years 1927-28, to 1930-31, inclusive

Year	Open lights		Closed lights		Lighting unknown		Total	
	Number of explosions	Per cent	Number of explosions	Per cent	Number of explosions	Per cent	Number of explosions	Per cent
1927-28	14	45.1	15	48.4	2	6.5	31	100
1928-29	18	47.4	19	50.0	1	2.6	38	100
1929-30	8	23.5	25	73.5	1	3.0	34	100
1930-31	12	44.4	15	55.6	0	0.0	1/ 27	100
1931-32	15	44.1	15	44.1	4	11.8	1/ 34	100
	67	40.9	89	54.3	8	4.8	2/164	100

1/ One mine had mixed (open as well as closed) lighting.
2/ Mines had mixed (open as well as closed) lighting.

It will be noticed that 89 or 54.3 per cent of the 164 explosions of the past five fiscal years took place in closed-light mines, 67 or 40.9 per cent in open-light mines, and 8 or 4.8 per cent in mines the lighting practice in which is unknown. The fact that 89 explosions or more than half of the explosions of the last five fiscal years in the mines of the United States occurred in closed-light mines is susceptible of numerous interpretations, but all of them must admit from the outset that not one explosion was started by an electric cap lamp. Generally the electric cap lamps have been installed only in mines known to have dangerous gas hazards; hence, the closed-light mines of the United States unquestionably include those mines which are inherently the most dangerous. When the closed lights are used, ventilation is much more likely to be neglected by the mine operator than when the hazard of open-light ignition is present, explosive gas is not as likely to be handled efficiently, and gas accumulations are likely to occur which are ignited by electric arcs or explosives, or possibly by surreptitious smoking. The miner uses the above as one of his main arguments against the installation of closed lights and his contention is borne out, at least in part, by the fact that of the 69 explosions of

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electrical origin in the past five fiscal years, at least 60 of them have occurred in closed-light mines; the miner himself very frequently contributes to the ignition of gas in closed-light mines by smoking, even when there is a State law or at least a company rule against smoking, as there should be in every closed-light mine. The answer to the above argument is not the continuance of the use of the unquestionably dangerous open lights in mines, but rather the use of closed lights and simultaneously of greater rather than less vigilence in ventilation--if necessary, by putting pressure on the mine operator through the law. Some explosions in closed-light mines are started by carelessness in the use of explosives, or by using dangerous and unsuitable explosives such as black powder or dynamite, or by using fuse. And oddly enough, some explosions in closed-light mines are started by open lights, used illegally, the offender sometimes being a mine official and sometimes a miner.

The miner is prone to resist the installation of the electric cap lamp, even though he knows the hazards of using the open lights and even though the up-to-date closed lights are safer, more dependable, and more efficient than any present-day open light used in mines. Hence, electric cap lamps generally are placed in mines under pressure and usually after a disaster has occurred through use of open lights, or possibly because the State inspection force pronounces the mine gassy and insists on the use of closed lights. In some relatively rare instances the mining company's officials adopt the electric cap lamps of their own volition, even though no disaster has occurred, because the real "up-and-coming" mining company realizes the numerous ultimate advantages of the up-to-date permissible electric cap lamps over any open-type mine-lighting equipment. Certainly at this time both safety and efficiency in our mines demand the use of the up-to-date permissible electric cap lamps exclusively for portable lighting; this applies to all types of underground workings in coal, metal, or nonmetallic mineral mines, where portable lights are used; and certainly no coal mine in the United States, gassy or so-called nongassy, should operate without using up-to-date closed lights for the miner.

Fires may present a serious hazard in any kind of mine, coal or metal, unless they are detected and handled soon after they start. While hundreds of fires occur every year in our mines, many if not most mining companies are now well prepared to detect and extinguish them promptly and without much damage or commotion, and the public hears so little about fires that most people including many mining executives, think that mines in general are not subject to the fire hazard; this is a decidedly erroneous belief, as practically all mines, coal or metal, are very definitely subject to hazards from possible fire occurrence. Notwithstanding the virtual universality of the fire hazard in mines, relatively few fires occur which are called to the attention of the outside world or in which outside help is required or desired. Table 6 gives some data on fires to which the attention of the safety division of the United States Bureau of Mines was called in the past fiscal year, as well as summations of such data for the two previous fiscal years.

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Table 6. - Summary of mine fires by States, July 1, 1931, to June 30, 1932

	Lights				Fatalities by ignition causes									
					Electricity		Open lights		Explosives		Miscellaneous		Total	
	Open	Closed	Un-known	Total	Deaths	Igni-tions	Deaths	Igni-tions	Deaths	Igni-tions	Deaths	Igni-tions	Deaths	Igni-tions
Alabama	-	2	-	2	0	1	-	-	-	-	0	1	0	2
Idaho	-	-	1	1	-	-	-	-	-	-	0	1/ 1	0	1/ 1
Indiana	-	-	1	1	-	-	-	-	0	1	-	-	0	1
Kentucky	3	-	-	3	0	1	-	-	0	1	0	1	0	3
Michigan	1	-	-	1	0	1/ 1	-	-	-	-	-	-	0	1/ 1
Pennsylvania.	-	2	5	7	0	1	-	-	-	-	0	6	0	7
Utah	1	-	-	1	0	1/ 1	-	-	-	-	-	-	0	1/ 1
Virginia	-	1	1	2	0	1	-	-	-	-	0	1	0	2
Washington ..	2	-	-	2	2/ 1	2/ 1	-	-	0	1	-	-	1	2/ 2
West Virginia	1	-	-	1	0	1	-	-	-	-	-	-	0	1
Total fiscal year ended June 30, 1932	8	5	8	21	1	8	-	-	0	3	0	10	1	21
Total fiscal year ended June 30, 1931 3/	12	7	5	24	0	7	5	3	0	5	18	9	23	24
Total fiscal year ended June 30, 1930 4/	7	8	9	24	2	9	3	6	0	3	0	6	5	24

1/ Metal mines.
2/ One of these two ignitions was in a metal mine.
3/ See Information Circular 6540, issued December, 1931.
4/ See Information Circular 6419, issued January, 1931.

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It will be seen that but one death is known to have been caused by mine fires in the United States in the fiscal year 1931-1932; this undoubtedly establishes a record for the past 50 years, and very probably is an all-time record in the history of mining in the United States. There were 23 deaths from mine fires in the previous fiscal year and 5 deaths in the year before that. Twenty-one fires occurred in mines of the United States in the past fiscal year to which the attention of the Bureau of Mines forces was called, or somewhat fewer than the 24 in each of the two previous fiscal years. Of these 21 mine fires last year, 8 were of electrical origin, and one of eight caused the one death of the year from fire. There were 7 fires of electrical origin in the previous fiscal year and 9 in the year before that. Three fires started by use or misuse of explosives in the past fiscal year were called to the attention of the forces of the safety division, there being 5 in the previous year and 3 in the year before that. Ten of the 21 mine fires in which Bureau of Mines aid was asked or to which the bureau's attention was directed last year were of miscellaneous origin, and generally this means spontaneous firing or fires in abandoned mines. Six of these fires of miscellaneous origin occurred in Pennsylvania, most of them in or near Pittsburgh where considerable trouble is encountered from smoldering fires in long abandoned mines or prospects, or in outcropping coal seams, some of them being within the corporate limits of Pittsburgh. Every year fires of the latter description, of which there were 9 in the previous fiscal year and 6 in the year before that, demand considerable attention from the United States Bureau of Mines forces.

CONCLUSION

In a period of intense economic distress, such as the past fiscal year, mining activities are decreased materially. In the retrenchments made necessary, safety measures usually suffer even more severely than the strictly operating features; this is very likely to result in greatly increased accident rates and accident occurrence, especially explosions and fires. In the past fiscal year this rule did not apply; although mining activities of nearly all types were severely curtailed, output reduced, and man-hours of work shortened, accident occurrence and accident rates fell instead of rising as might have been expected from past experience; and this decrease included accidents from explosions as well as from the other major causes. Not since 1921 has any year in mining in the United States had as few fatalities from explosions as the 87 in the fiscal year 1931-1932; and an analysis of what has occurred gives hope for the continuance of mine operation with reasonable immunity from explosion disasters.

The decrease in the demand for mining products, together with the large available supply, has acted with other agencies to reduce the margin of profit to a minimum, and this in turn has forced operating executives to examine the items of cost of production much more carefully than in the past. The result has been that the progressive mine executives now find that the various factors entering into the cost of accidents aggregate at least 5 per cent and, in many instances as much as 10 or even 15 per cent of the cost of production. This has led some of the wide-awake executives to make a determined attempt to reduce accident occurrence (including explosions and fires) at

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their properties, and in most cases where this effort is accompanied with a reasonable amount of personal attention by the officials, material reductions have been achieved. Some of these successful efforts have become known to other operators, and this has led to numerous "follow ups," admirable reductions in occurrence of mine accidents (including gas and dust ignitions and mine fires), and to material savings in dollars and cents to the operators in addition to savings in suffering and in life and limb to the workers.

Probably the most significantly encouraging fact brought out by the study of explosions and fires in the mines of the United States during the fiscal year 1931-32 is that explosions of electrical origin cost the lives of but 11 persons, against an average of 137 annually for the past five years; moreover, it is distinctly encouraging to note that in the past fiscal year but 12.7 per cent of those killed in explosions in the mines of the United States were killed in explosions of electrical origin as against an average of 69.4 per cent (or nearly 70 per cent) annually for the past five years, this percentage being 82.5 for the fiscal year 1927-28. One of the most alarming features in connection with safety in the mines of the United States in recent years has been the carelessness with which electricity in various forms was being installed beginning about 1917 or 1918 and with particular activeness in 1925, 1926, 1927, and 1928. The resultant fires and explosions were numerous and decidedly costly in life and property. Evidently the electrical installations are now being made more carefully, or safer equipment is being placed and maintained, or ventilation is being handled more carefully than in the past; possibly all of these factors are responsible to some extent. In addition, there are other influences, an important one being more intensive supervision and inspection of electrical equipment in mines. Unquestionably, luck is a factor in the avoidance of electrically initiated explosions, as there certainly is in many mines much unsafe electrical equipment and much electrical equipment operating under unsafe conditions as to explosive gas or dust, especially electrically operated loading, conveying, and similar machinery being used at or near the working faces. During the past fiscal year at least three explosions of electrical origin were prevented by rock-dust from extending or propagating; it is entirely probable that if rock-dusting had not been done in these mines or the dust had not been in effective working condition, the death list from the three explosions would have been in excess of 300, as the amounts of natural gas and dust present were such as to aid in the extension of an explosion.

The bituminous properties of Pennsylvania, comprising more than 1,300 mines with over 125,000 employed, continue to have a wonderful record as to the avoidance of major explosions, there having been no major explosion disaster in a bituminous mine in Pennsylvania from March 21, 1929, to date of writing this paper (November 10, 1932), or for nearly 3-2/3 years, a record of which all persons in bituminous coal mining may well be proud. The anthracite mines of Pennsylvania, with their intricate and extensive workings, numerous hazardous conditions, and employment of about 150,000 persons have not had a major explosion since May 29, 1931, or practically 1½ years, also a noteworthy achievement. West Virginia with its approximately 100,000 employees and its more than 800 mines, many of them with decidedly hazardous

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conditions as to gas and dust, has operated since November 3, 1931, or over a year without a major explosion; and numerous other States have in recent years established safety records (including avoidance of loss of life by explosions and fires) which would have been considered absolutely impossible as late as 10 years ago. In the calendar year 1932 to November 10, all of the coal-mining States except one have had a most excellent safety record, not only as to occurrence of the usual types of accidents, but also as to major explosion disasters; there has not been a major explosion disaster in any coal mine in the United States, anthracite or bituminous, except in Virginia, which has the very bad record of three major explosion disasters with 54 deaths.

Mining companies are now realizing that explosions and fires are preventable and that the cost of the readily available measures for their prevention is far less than the numerous expenses which result from a fire or an explosion even if no loss of life should occur. There is much reason for the belief that fire and explosion disasters in our mines will be of far less frequency or severity in the future than in the recent past. Moreover, it is now pretty well established that when an explosion or fire results in loss of life or of property, negligence has been the underlying cause; and in the future little or no credence will be given to any assigned cause other than negligence for the occurrence of an explosion or fire disaster. The negligence may be due to poor mining practices or poor machinery installation or equipment, lack of supervision or faulty supervision, or to numerous other deficiencies on the part of the management and probably to an equally great number of "failures" on the part of the workers. Certainly we can not hope to eliminate fires and explosions in coal mines as long as our mining people continue to use open lights, black powder, dynamite, fuse, and nonpermissible electrical machinery and equipment; nor can these disasters be prevented from occurring from time to time until our underground workers are in some manner impressed with the idea that State mining laws and regulations and company rules are generally, almost invariably, made for the protection of the workers, and that in violating these laws or regulations or rules a man may be risking not only his own life but also the lives of many if not all of his fellow workers.

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